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## PATENT ABSTRACTS OF JAPAN

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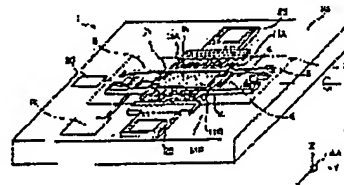
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(54) ANGULAR VELOCITY SENSOR

(57)Abstract:

PROBLEM TO BE SOLVED: To provide an angular velocity sensor for detecting accurately the rotational angular velocity around a Y-axis on an X-Y 2-dimensional plane.

SOLUTION: A planar vibration body 3 is constituted of a combined body, wherein a weight vibration body 5 is connected inside a rectangular frame body 6 via a connection beam 4, supported with a supporting beam 8 which is oscillatable in an X-direction. Mobile electrodes 11A and 11B are protruded at an outside end part of the frame body 6, while fixed electrodes 13A and 13B are provided on the facing side. The weight vibration body 5 is a vertical movement side electrode, with a lower part electrode 16 provided on the facing. Related to the connection beam 4, the rigidity in a Z-axis direction of the direction for detecting vibrating direction of the weight vibration body 5 is made smaller than that in the X-direction of the direction for detecting the vibration direction of the plane vibration body 3, while, relating to the supporting beam 8, the rigidity in the X-direction is made smaller than that in the Z-direction. The planar vibration body 3 is oscillated in the X-direction to cause Coriolis force in the Z-direction by rotation around a Y-axis, when only the weight vibration body 5 of the planar vibration body 3 is oscillated in the Z-direction for detecting an angular velocity about the Y-axis.



## DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[The technical field to which invention belongs] this invention relates to the angular-velocity sensor which detects angular velocity.

[0002]

[Description of the Prior Art] The angular-velocity sensor using the minute vibrator by micro-machining is developed, and the angular-velocity sensor which these people proposed to JP,8-184448,A is shown in drawing 6. As shown in this drawing, the angular-velocity sensor 1 has the flat-surface oscillating object 3, the weight oscillating object 5 is connected through the connection beam 4 inside a frame 6, and the flat-surface oscillating object 3 is formed with the joint object of a frame 6 and the weight oscillating object 5. Also having a function as a perpendicular slip lateral electrode besides the weight oscillating object 5 functioning as an oscillating object, the group of this weight oscillating object 5 and the lower electrode 16 functions also as a circumference angular-velocity detection electrode of a Y-axis which detects the vibration amplitude of Z shaft orientations of the weight oscillating object 5 corresponding to angular-velocity change of rotation of the circumference of a Y-axis by detecting change of the electrostatic capacity between the weight oscillating object 5 and the lower electrode 16.

[0003] This flat-surface oscillating object 3 minds [ fixed / 21 ] the supporting beam 8 of a hook presser-foot-stitch-tongue configuration (the shape of a KO typeface). Vibration of the direction of X of X and 2 Y-dimensional flat surface and the direction of Y is supported possible. The mobile electrodes 10A, 10B, 11A, and 11B of a ctenidium electrode are formed in the heel of a frame 6, and fixed electrodes 12A, 12B, 13A, and 13B are formed in the fixed substrate 21 side through mobile electrodes 10A, 10B, 11A, and 11B and the interval. The group of mobile electrodes 11A and 11B and fixed electrodes 13A and 13B is constituted as an excitation electrode which vibrates the flat-surface oscillating object 3 in the direction of X by electrostatic force.

[0004] The perpendicular slip lateral electrode which is not illustrated is prepared in the aforementioned weight oscillating object 5, and the lower electrode 16 as a fixed counterelectrode is formed in the opposite side through this perpendicular slip lateral electrode and interval.

[0005] In the angular-velocity sensor of this proposal, it is adjusted so that the resonance frequency of vibration of the direction of X in the flat-surface oscillating object 3 and the resonance frequency of Z shaft orientations (Z direction) in the weight oscillating object 5 may be mostly in agreement, and the weight oscillating object 5 and a frame 6 have the resonance frequency from which the resonance frequency of vibration of a Z direction differs mutually by this adjustment.

[0006] In this sensor, by mobile electrodes 11A and 11B and fixed electrodes 13A and 13B, where the flat-surface oscillating object 3 is vibrated in the direction of X by electrostatic force, an operation of rotation of the circumference of a Y-axis generates the Coriolis force shown in the following formula (1) at the Z direction which intersects perpendicularly with both the oscillating direction (the direction of X), and the direction of the axis of rotation (the direction of Y).

[0007]

$F_c = 2m \cdot V \cdot \omega$  ..... (1)

[0008] In addition, in a formula (1), it is the angular velocity (degree/s) on which Coriolis force and m act on in  $F_c$ , and the speed at the time of the drive of vibrator (m/s) and  $\omega$  act in the mass (kg) of vibrator, and V.

[0009] If it does so, it will set in the angular-velocity sensor 1 of a proposal. As mentioned above, it is adjusted so that the resonance frequency of vibration of the direction of X in the flat-surface oscillating object 3 and the resonance frequency of vibration of the Z direction in the weight oscillating object 5 may be mostly in agreement. From having the resonance frequency from which the resonance frequency of vibration of a Z direction differs mutually, the weight oscillating object 5 and a frame 6 Only the weight oscillating object 5 of the flat-surface oscillating object 3 vibrates to a Z direction greatly, and the size of the angular rate of rotation of the circumference of a Y-axis

etc. is detected by the aforementioned Coriolis force based on change of the electrostatic capacity between the base electrode of the weight oscillating object 5, and the lower electrode 18.

[0010] Moreover, since, as for a frame 6 and mobile electrodes 11A and 11B, the resonance frequency of vibration of the Z direction of a frame 6 and the weight oscillating object 5 differed at this time and it hardly vibrated to a Z direction, mobile electrodes 11A and 11B did not shift to fixed electrodes 13A and 13B, and the flat-surface oscillating object 3 was presupposed that excitation vibration can be performed in the size of the always stabilized vibration amplitude.

[0011]

[Problem(s) to be Solved by the Invention] However, by making resonance frequency of vibration of the Z direction of the weight oscillating object 5 and a frame 6 into mutually different resonance frequency like the above Although it is theoretically possible to vibrate a Z direction greatly and to make it a frame 6 not almost vibrate only the weight oscillating object 5 to a Z direction by the Coriolis force of a Z direction The flat-surface oscillating object 3 is what is supported by the KO typeface-like supporting beam 8 and is attached in the fixed substrate 21. the weight oscillating object 5 Since it is that by which height and width of face are prepared in the frame 6 through the connection beam 4 of the almost same thickness, if the weight oscillating object 5 vibrates to a Z direction, a frame 6 will also vibrate somewhat to a Z direction in fact. And these people have noticed trouble appearing in the function not to restrict that excitation vibration of the vibration amplitude always stabilized as mentioned above by the flat-surface oscillating object 3 can be performed since mobile electrodes 11A and 11B also vibrate to a Z direction, but to detect the size of the angular rate of rotation of the circumference of a Y-axis with high degree of accuracy by vibration of the Z direction of a frame 6, somewhat.

[0012] It is made in order that this invention may solve the above-mentioned technical problem, and the purpose vibrates an oscillating object in the direction of X, and it suppresses that the whole oscillating object vibrates to a Z direction by the Coriolis force produced by rotation of the circumference of a Y-axis, and is in offering the angular-velocity sensor which can detect very correctly the angular rate of rotation of the circumference of a Y-axis.

[0013]

[Means for Solving the Problem] In order to attain the above-mentioned purpose, this invention has the following composition and makes it the The means for solving a technical problem. Namely, a weight oscillating object is connected through a connection beam inside a frame, and, as for the 1st invention, a flat-surface oscillating object is formed with the joint object of a frame and a weight oscillating object. As for this flat-surface oscillating object, vibration of the direction of X of X and 2 Y-dimensional flat surface is supported by the fixed substrate possible through the supporting beam. A mobile electrode is prepared in the heel of the aforementioned frame, and a fixed electrode is prepared in a fixed substrate side through this mobile electrode and an interval. Moreover, a fixed counterelectrode is prepared in the opposite side which minded this perpendicular slip lateral electrode and the interval while the perpendicular slip lateral electrode was prepared in the aforementioned weight oscillating object. The group of the aforementioned mobile electrode and a fixed electrode is constituted as an excitation electrode which vibrates a flat-surface oscillating object in the direction of X by electrostatic force. The group of the aforementioned perpendicular slip lateral electrode and a fixed counterelectrode is constituted as a circumference angular-velocity detection electrode of a Y-axis which detects the above X of the weight oscillating object corresponding to angular-velocity change of rotation of the circumference of a Y-axis, and the vibration amplitude of Z shaft orientations perpendicular to Y flat surface. The aforementioned connection beam is formed smaller than the rigidity of the direction of X whose rigidity of Z shaft orientations used as the detection oscillating direction of the aforementioned weight oscillating object is the oscillating direction of a flat-surface oscillating object. The rigidity of the direction of X which is the oscillating direction of the aforementioned flat-surface oscillating object makes the aforementioned supporting beam the The means for solving a technical problem with the composition currently formed smaller than the rigidity of Z shaft orientations used as the detection oscillating direction of the aforementioned weight oscillating object.

[0014] Moreover, in the 2nd invention, in addition to the composition of invention of the above 1st, the weight oscillating object is presenting the square configuration. The connection beam is presenting the L character configuration and the nose-of-cam side of the shorter side of the L character configuration of a connection beam is connected to the four-corners section of a weight oscillating object, respectively. The long side of the L character configuration of each connection beam is made into the The means for solving a technical problem with the composition in which it \*\*\*\* towards the corner of the opposite side of the corner where the side of a weight oscillating object is made to meet through an interval in, and the nose-of-cam side of the shorter side of the aforementioned L character configuration is connected, and the \*\*\*\* nose-of-cam side is connected to the frame side.

[0015] Furthermore, in addition to the composition of invention of the above 1st, the 3rd invention makes the connection beam the The means for solving a technical problem with the composition prepared in the direction of Y which intersects perpendicularly with the direction of X used as the oscillating direction of a flat-surface oscillating object.

[0016] In addition to the above 1st or any one composition of the 3rd invention, 4th invention is taken as the composition which prepared the electrostatic-force impression electrode for impressing electrostatic force to a fixed substrate side through a weight oscillating object and an interval at a weight oscillating object. By impressing direct current voltage to an electrostatic-force impression electrode; and impressing electrostatic force to a weight oscillating object, resonance frequency can be adjusted to the Z direction of a weight oscillating object, and angular velocity can be detected now with high density by tuning resonance frequency finely.

[0017] In this invention of the above-mentioned composition, a weight oscillating object is connected through a connection beam inside a frame, and a flat-surface oscillating object is formed with the joint object of a frame and a weight oscillating object. The aforementioned connection beam is formed smaller than the rigidity of the direction of X whose rigidity of Z shaft orientations used as the detection oscillating direction of the aforementioned weight oscillating object is the oscillating direction of a flat-surface oscillating object. Since the aforementioned supporting beam is formed smaller than the rigidity of Z shaft orientations from which the rigidity of the direction of X which is the oscillating direction of the aforementioned flat-surface oscillating object serves as the detection oscillating direction of the aforementioned weight oscillating object A flat-surface oscillating object tends to vibrate in the direction of X which is the oscillating direction, it is hard to vibrate to the Z direction used as the detection oscillating direction of a weight oscillating object, on the other hand, a weight oscillating object cannot vibrate easily in the direction of X which is the oscillating direction of a flat-surface oscillating object, and it is easy to vibrate to the Z direction which becomes with the detection direction of a weight oscillating object.

[0018] Therefore, when a flat-surface oscillating object vibrates in the direction of X and the Coriolis force of a Z direction arises by rotation of the circumference of a Y-axis, only a weight oscillating object vibrates greatly to a Z direction, the frame of a flat-surface oscillating object hardly vibrates to a Z direction, but vibration of a flat-surface oscillating object by the stable vibration amplitude is attained, the angular rate of rotation of the circumference of a Y-axis is detected with a sufficient precision by this Coriolis force, and the above-mentioned technical problem is solved.

[0019]

[Embodiments of the Invention] Hereafter, the gestalt of operation of this invention is explained based on a drawing. In addition, in explanation of this example of an operation gestalt, the same sign is given to the same name portion as the angular-velocity sensor shown in drawing 6, and the duplication explanation is omitted. The vibrator composition of the example of 1 operation gestalt of the angular-velocity sensor concerning this invention is shown to drawing 1 by the perspective diagram. The angular-velocity sensor 1 of this example of an operation gestalt has the flat-surface oscillating object 3, mobile electrodes 11A and 11B, fixed electrodes 13A and 13B, the supporting beam 8, and the lower electrode 16 like the angular-velocity sensor 1 shown in drawing 6, through the connection beam 4, the weight oscillating object 5 is connected inside the right-angled quadrilateral-like frame 6, and the flat-surface oscillating object 3 is formed in it.

[0020] Moreover, the group of mobile electrodes 11A and 11B and fixed electrodes 13A and 13B is constituted as an excitation electrode which vibrates the flat-surface oscillating object 3 in the direction of X by electrostatic force, and the group of the perpendicular slip lateral electrode of the weight oscillating object 5 and the lower electrode 16 is constituted as a circumference angular-velocity detection electrode of a Y-axis which detects the vibration amplitude of the Z direction of the weight oscillating object 5 corresponding to angular-velocity change of rotation of the circumference of a Y-axis. In addition, 20 in drawing shows the connection electrode to the weight oscillating object 5.

[0021] It is that the characteristic thing which this example of an operation gestalt differs from the angular-velocity sensor 1 shown in drawing 6 is formed small than the rigidity of the direction of X whose rigidity of the shaft orientations Z from which the connection beam 4 serves as the detection oscillating direction of the weight oscillating object 5 is the oscillating direction of a flat-surface oscillating object 3, and a supporting beam 8 is small formed rather than the rigidity of the Z direction from which the rigidity of the direction of X which is the oscillating direction of the flat-surface oscillating object 3

[0022] Specifically, although the angular-velocity sensor 1 of this example of an operation gestalt forms the vibrator which processed the silicon layer 25 with a thickness of 50 micrometers, and was equipped with the flat-surface oscillating object 3 and the supporting beam 8 on the glass substrate 23, the connection beam 4 was locally processed into about 5 micrometers in thickness thinly, and has accomplished the beam width with 50 micrometers. The rigidity of Z shaft orientations is formed like the above smaller than the rigidity of X shaft orientations by making the detection beam 4 into 5 micrometers in thickness to width of face of 50 micrometers in this way. The beam width has accomplished the aforementioned supporting beam 8 with 5 micrometers, in this way, since thickness has accomplished with 50 micrometers like the above to 5 micrometers, the rigidity of the direction of X is smaller than the rigidity of Z shaft orientations, and the beam width is formed.

[0023] Moreover, in this example of an operation gestalt, unlike the angular-velocity sensor 1 shown in drawing 6, the detection beam 4 is formed only in the right-hand side of drawing two, the connection beam 4 is formed in the direction of Y which intersects perpendicularly with the direction of X used as the oscillating direction of the flat-surface oscillating object 3, and the weight oscillating object 5 is connected to the side on the right-hand side of drawing of the right-angled quadrilateral-like frame 6 by the connection beam 4.

[0024] Furthermore, in this example of an operation gestalt, it is adjusted so that the resonance frequency of vibration of the direction of X in the flat-surface oscillating object 3 and the resonance frequency of vibration of the Z direction in a weight oscillating object may be mostly in agreement, and by doing in this way, it is adjusted so that the resonance frequency in drive mode and the resonance frequency in detection mode may be mostly in agreement.

[0025] Specifically, since vibration of the direction of X of the flat-surface oscillating object 3 is performed by being supported by the supporting beam 8, the resonance frequency in drive mode is decided by the size of a supporting beam 8. Moreover, if the weight oscillating object 5 vibrates to Z shaft orientations by the Coriolis force of Z shaft orientations produced in rotation of the circumference of the Y-axis by excitation of the direction of X of the flat-surface oscillating object 3, since this vibration will be performed by being supported by the connection beam 4, the resonance frequency in detection mode is decided by the size of the connection beam 4. Therefore, these sizes are designed in a suitable size and the resonance frequency in drive mode and detection mode is made in agreement in this example of an operation gestalt. For example, when the resonance frequency in detection mode is higher than the resonance frequency in drive mode, by trimming the connection beam 4 by focused-ion-beam processing etc., resonance frequency in detection mode is made low and it is made in agreement with the resonance frequency in drive mode.

[0026] This example of an operation gestalt is constituted as mentioned above, next explains the production process of the angular-velocity sensor 1 of this example of an operation gestalt based on drawing 2 and 3. First, as shown in (a) of drawing 2, the hollow used as a cavity 24 is formed

in the front-face side of a glass substrate 23, and as shown in (b) of this drawing, the lower electrode 16 is formed in a cavity 24. On the other hand, as shown in (a') of this drawing, it embeds at the with a thickness of 50 micrometers upper part side of a barrier layer Si 33, and SiO<sub>2</sub>32 is carried out, and as the SOI (Silicon On Insulator) substrate which formed supporters Si 31 in the upper part side, and formed SiO<sub>2</sub>30 in the upper part side further is prepared and it is shown in (b') of this drawing, SiO<sub>2</sub>30 of a front face is \*\*\*\*\*ed further. And as shown in (c) of this drawing, anode plate junction of the SOI substrate after SiO<sub>2</sub> etching is carried out at the upper part side of a glass substrate 23. In addition, 34 in drawing shows a junction interface.

[0027] Next, as shown in (d) of this drawing, the supporters Si 31 of a SOI substrate are removed by etching by alkaline-water solutions, such as dry etching or KOH, and as shown in (e) of this drawing, the embedding SiO<sub>2</sub>32 which is an insulator layer is removed further.

[0028] Next, as shown in (a) of drawing 3, patterning of the resist 35 is applied and carried out to the front-face side of a barrier layer Si. In addition, this patterning is patterning for forming the connection beam 4. Next, as shown in (b) of this drawing, the barrier layer Si 33 of the portion used as the connection beam 4 is \*\*\*\*\*ed to 5 micrometers in thickness by using a resist 35 as a mask, and a resist 35 is removed. Next, vibrator is produced by carrying out perpendicular processing until it carries out dry etching of the barrier layer Si by using a resist 35 as a mask and reaches a glass substrate 23, as are shown in (c) of this drawing, and it carries out patterning, using a resist 35 as a mask and it is shown in (d) of this drawing.

[0029] It separates into a chip by the dicer etc., and the packaging of the vibrator on the glass substrate 23 produced at such a process is carried out together with detection / drive circuit etc., and let it be the angular-velocity sensor 1. In addition, in order that the angular-velocity sensor 1 of this example of an operation gestalt may avoid the influence of damping of air, by carrying out a vacuum package and adjusting the pressure inside a package etc., it adjusts Q (Quality Factor) value in detection mode to the optimal value, and produces the angular-velocity sensor which was able to balance sensitivity and stability.

[0030] Although the angular-velocity sensor 1 of this example of an operation gestalt is produced as mentioned above and the flat-surface oscillating object 3 is excited in the direction of X within the same flat surface as the flat-surface oscillating object 3 in this angular-velocity sensor 1 by the electrostatic force between mobile electrodes 11A and 11B, fixed electrode 13A, and 13B The weight oscillating object 5 seems not to blur in the direction of X to a frame 6 by this excitation, even if it excites the flat-surface oscillating object 3 in the direction of X, since the rigidity of Z shaft orientations is formed smaller than the rigidity of the direction of X and the connection beam which supports the weight oscillating object 5 cannot vibrate easily in the direction of X.

[0031] And if the flat-surface oscillating object 3 excites in the direction of X and rotates a Y-axis as a center, although the Coriolis force of a Z direction will arise In this example of an operation gestalt, the rigidity of a Z direction is larger than the rigidity of the direction of X, and the supporting beam 8 which supports the flat-surface oscillating object 3 is formed. To the Z direction, have accomplished with the composition of being hard to vibrate that it is easy to vibrate in the direction of X, and, on the other hand, the connection beam 4 which supports the weight oscillating object 5 Since it is easy to vibrate to a Z direction and is constituted that the rigidity of a Z direction is smaller than the rigidity of the direction of X like the above, and it is formed, and is hard to vibrate in the direction of X, by the Coriolis force of a Z direction, only the weight [ of the flat-surface oscillating object 3 ] oscillating object 5 is large, and it vibrates to a Z direction, and a frame 6 hardly vibrates to a Z direction. And based on change of the electrostatic capacity between the base electrode of the weight oscillating object 5, and the lower electrode 16, the size of the angular rate of rotation of the circumference of a Y-axis etc. is detected.

[0032] Moreover, since only the weight oscillating object 5 vibrates and mobile electrodes 11A and 11B do not vibrate to Z shaft orientations united with a frame 6 when the Coriolis force of Z shaft orientations is applied to the flat-surface oscillating object 3, mobile electrodes 11A and 11B do not shift to fixed electrodes 13A and 13B, and the flat-surface oscillating object 3 performs excitation vibration in the size of the always stabilized vibration amplitude.

[0033] By having formed smaller than the rigidity of the direction of X the rigidity of the Z

direction of the connection beam 4 which connects this example \*\*\*\*\* of an operation gestalt, a frame 6, and the weight oscillating object 5, and having formed smaller than the rigidity of Z shaft orientations the rigidity of the direction of X of the supporting beam 8 which supports the flat-surface oscillating object 3. When the flat-surface oscillating object 3 vibrates in the direction of X and rotates to the circumference of a Y-axis, only the weight oscillating object 5 vibrates to Z shaft orientations, and a frame 6 can be prevented from almost vibrating to a Z direction. Therefore, the mobile electrodes 11A and 11B which are excitation electrodes do not shift to Z shaft orientations to fixed electrodes 13A and 13B, and the flat-surface oscillating object 3 can always be stabilized in the size of an amplitude for the voltage impressed to mobile electrodes 11A and 11B or fixed electrodes 13A and 13B, can carry out excitation vibration, and can detect the angular rate of rotation of the circumference of a Y-axis with a sufficient precision.

[0034] Moreover, according to this example of an operation gestalt, from the rigidity of the connection beam 4, and the rigidity of a supporting beam 8 like the above, and it considers as the composition which cannot vibrate easily in the direction of X that the weight oscillating object 5 tends to vibrate to Z shaft orientations. Since it considered as the composition which cannot vibrate easily to Z shaft orientations that a frame 6 tends to vibrate in the direction of X, and the resonance frequency in drive mode can be decided with the size of a supporting beam 8 and the oscillation frequency in detection mode can be decided with the size of the connection beam 4. It becomes possible to make in agreement easily the resonance frequency of excitation vibration of the direction of X of the flat-surface oscillating object 3 and the resonance frequency of vibration of the Z direction of the weight oscillating object 5, and let sensitivity of the angular-velocity sensor 1 be a high thing.

[0035] Furthermore, like the angular-velocity sensor 1 shown in drawing 6, if formed in the same direction as the direction of X which is the oscillating direction of the flat-surface oscillating object 3, the connection beam 4. From the acceleration produced when vibrating the flat-surface oscillating object 3 arising in the connection beam 4 and this direction. It will work in the direction in which the force produced in the resultant-force direction of this acceleration and gravity makes the weight oscillating object 5 go up and down, and change will arise by the change component of this vertical direction in the electrostatic-capacity change between the base electrode of the weight oscillating object 5, and the lower electrode 16. If it becomes so, although trouble will arise for the precision of angular-rate-of-rotation detection of the circumference of a Y-axis etc. By having formed the connection beam 4 in the direction of Y which intersects perpendicularly with the direction of X used as the oscillating direction of the flat-surface oscillating object 3 in this example of an operation gestalt. Since it generates in the direction of torsion of the weight oscillating object 5 and the change component of the vertical direction does not produce the moment by the acceleration produced by vibration of the flat-surface oscillating object 3. The Coriolis force produced in Z shaft orientations cannot be affected, and angular-rate-of-rotation detection of the circumference of a Y-axis can be performed with a much more sufficient precision.

[0036] Furthermore, since thickness of vibrator can be thickened [ according to this example of an operation gestalt ] in the range which can be etched unlike the case where produce vibrator by drawing 2 and the method as shown in 3, for example, carry out dry etching processing of contest the polysilicon or single-crystal-silicon layer on a substrate, and vibrator is produced, it can become possible to enlarge mass of vibrator and the sensitivity of an angular-velocity sensor can be raised further. In addition, since only the thickness of the connection beam 4 is thin among the thickness of vibrator, even if the length of the connection beam 4 is short, it becomes possible [ making resonance frequency of Z shaft orientations low ], can make the resonance frequency of Z shaft orientations of the weight oscillating object 5, and the resonance frequency of the direction of X of the flat-surface oscillating object 3 mostly in agreement, can be used as small vibrator, and can miniaturize the angular-velocity sensor 1.

[0037] The composition of the flat-surface oscillating object 3 in the example of the 2nd operation gestalt of the angular-velocity sensor concerning this invention is shown in drawing 4. In addition, the plan is shown in (a) of this drawing, and the A-A' cross section of (a) is shown in (b) of this



drawing. As shown in this drawing, the weight oscillating object 5 of the flat-surface oscillating object 3 is presenting the square configuration, the connection beam 4 is presenting the L character configuration, and the nose-of-cam side of the shorter side 26 of the L character configuration of the connection beam 4 is connected to the four-corners section of the weight oscillating object 5, respectively. Moreover, the long side 27 of the L character configuration of each connection beam 4 is made to meet the side of the weight oscillating object 5 through an interval, is \*\*\*\*(ed) towards the corner where the L character nose-of-cam side of the shorter side 26 of a configuration is connected, and the \*\*\*\* nose-of-cam side is connected to the frame 6 side.

[0038] Composition other than the above of this example of an operation gestalt is the same as that of the above-mentioned example of the 1st operation gestalt, this example of an operation gestalt can also be produced by the same production method as the above-mentioned example of the 1st operation gestalt, and can operate similarly, and can do the same effect so.

[0039] Moreover, since it is easy to make in agreement the resonance frequency of Z shaft orientations of the weight oscillating object 5, and the resonance frequency of the direction of X of the flat-surface oscillating object 3 when connecting the weight oscillating object 5 and a frame 6 using four connection beams 4 and it is connected as mentioned above like this example of an operation gestalt, using the connection beam 4 as a L character configuration, sensitivity of the angular-velocity sensor 1 can be made high.

[0040] In addition, this invention is not limited to each above-mentioned example of an operation gestalt, and can take the mode of various operations. For example, although the fixed-end side of a supporting beam 8 smelled and bending formation was carried out in the above-mentioned example of an operation gestalt at the presser-foot-stitch-tongue configuration, especially the configuration of a supporting beam 8 is not limited and is suitably set as the configuration which can support the flat-surface oscillating object 3 possible [ vibration ] in the direction of X of X and 2 Y-dimensional flat surface.

[0041] Moreover, in each above-mentioned example of an operation gestalt, although mobile electrodes 11A and 11B and fixed electrodes 13A and 13B considered as the ctenidium electrode, necessarily, even if it uses mobile electrodes 11A and 11B and fixed electrodes 13A and 13B as a ctenidium electrode, they are not restricted, but an electrode configuration is set up suitably.

[0042] Furthermore, although the weight oscillating object 5 not only functions as an oscillating object, but it was functioning as a perpendicular slip type electrode in each above-mentioned example of an operation gestalt, you may prepare a separate perpendicular slip type electrode in the weight oscillating object 5.

[0043] Furthermore, although the connection beam 4 was formed in the direction of Y which intersects perpendicularly with the direction of X which is the oscillating direction of the flat-surface oscillating object 3 in the above-mentioned example of the 1st operation gestalt, you may form the connection beam 4 in the direction of X like the angular-velocity sensor 1 shown in drawing 6. However, since the angular rate of rotation of the circumference of a Y-axis can be detected very correctly, without being influenced of the acceleration produced by vibration like the above by forming the connection beam 4 in the direction of Y, as for the connection beam 4, preparing in the direction of Y is desirable.

[0044] Furthermore, in each above-mentioned example of an operation gestalt, as shown in (a) of drawing 5, and (b), the electrostatic-force impression electrode 14 for impressing electrostatic force to the weight oscillating object 5 can be formed in the fixed substrate 23 side through the weight oscillating object 5 and an interval. if direct current voltage is impressed to the electrostatic-force impression electrode 14 -- the weight oscillating object 5 -- electrostatic force -- acting -- this -- a static -- it acts on the weight oscillating object 5 as a \*\*\*\* spring That is, when the weight oscillating object 5 vibrates to a Z direction, in order that electrostatic force may act in the direction which increases an amplitude, it is effective in generating the force of a mechanical spring and opposite direction, and the resonance frequency of the weight oscillating object 5 is reduced as a result. Therefore, resonance frequency can be finely tuned from the peculiar resonance frequency of the weight oscillating object 5 to a low frequency side by adjusting the size of direct current voltage. If this effect is used and the peculiar resonance frequency of the weight

oscillating object 5 will be slightly designed highly from the high sensitivity resonance frequency, it can tune finely to the high sensitivity resonance frequency by adjustment of direct current voltage. In addition, the sectional side elevation of the example in which (a) of drawing 5 formed the electrostatic-force impression electrode 14 in the above-mentioned example of the 1st operation gestalt, and (b) show the sectional side elevation of an example which formed the electrostatic-force impression electrode 14 in the above-mentioned example of the 2nd operation gestalt.

[0045]

[Effect of the Invention] According to this invention, the supporting beam which supports the flat-surface oscillating object with which the weight oscillating object was connected through the connection beam inside the frame is formed smaller than the rigidity of Z shaft orientations from which the rigidity of the direction of X which is the oscillating direction of a flat-surface oscillating object serves as the detection oscillating direction of a weight oscillating object. It can be made hard to vibrate in the direction of X that a flat-surface oscillating object cannot vibrate easily to a Z direction that it is easy to vibrate in the direction of X, and a weight oscillating object tends to vibrate to the reverse at a Z direction since the aforementioned connection beam is smaller than the rigidity of the aforementioned X direction and the rigidity of the aforementioned Z shaft orientations is formed.

[0046] Therefore, if it rotates to Y shaft orientations by vibration of the direction of X of a flat-surface oscillating object and Coriolis force occurs in Z shaft orientations, since only a weight oscillating object will vibrate greatly to Z shaft orientations and the frame of a flat-surface oscillating object will hardly be changed to Z shaft orientations by Coriolis force, For example, in the size of the beam width for the voltage impressed to either of the mobile electrode prepared in the frame, and a mobile electrode and the fixed electrode prepared through the interval, it is always stabilized, can carry out excitation vibration, and a flat-surface oscillating object The angular rate of rotation of the circumference of the Y-axis detected by vibration of a weight oscillating object is correctly detectable.

[0047] Moreover, since according to this invention a frame cannot vibrate easily to the aforementioned Z shaft orientations that it is easy to vibrate in the aforementioned X direction and a weight oscillating object tends to vibrate to Z shaft orientations by constituting the rigidity of a supporting beam and a connection beam like the above that it is hard to vibrate in the aforementioned X direction, the resonance frequency of Z shaft orientations of a weight oscillating object can be determined with the size of a connection beam, and the resonance frequency of the direction of X of a flat-surface oscillating object can Therefore, it becomes possible to make in agreement easily the resonance frequency of Z shaft orientations of a weight oscillating object and the resonance frequency of the direction of X of a flat-surface oscillating object, and it can consider as the angular-velocity sensor of high sensitivity easily by carrying out abbreviation coincidence of both the resonance frequency.

[0048] Moreover, the weight oscillating object is presenting the square configuration and the connection beam is presenting the L character configuration. The nose-of-cam side of the shorter side of the L character configuration of a connection beam is connected to the four-corners section of a weight oscillating object, respectively. According to the angular-velocity sensor of this invention by which the long side of the L character configuration of an angle connection beam is \*\*\*\*(ed) towards the corner of the opposite side of the corner where the side of a weight oscillating object is made to meet through an interval in, and the nose-of-cam side of the shorter side of the aforementioned L character configuration is connected, and the \*\*\*\* nose-of-cam side is connected to the frame side By constituting the configuration of a connection beam, and the connection state of the weight oscillating object of a connection beam, and a frame like the above, it can carry out that it is very easy to make in agreement the resonance frequency of Z shaft orientations of a weight oscillating object, and the resonance frequency of the direction of X of a flat-surface oscillating object.

[0049] Furthermore, since a connection beam can prevent the acceleration produced by vibration of a flat-surface oscillating object acting in the vertical direction to a weight oscillating object

according to this invention prepared in the direction of Y which intersects perpendicularly with the direction of X used as the oscillating direction of a flat-surface oscillating object, it can detect further the angular rate of rotation of the circumference of a Y-axis to accuracy, without being influenced of the aforementioned acceleration.

[0050] By considering as the composition which prepared the electrostatic-force impression electrode for impressing electrostatic force to a fixed substrate side through a weight oscillating object and an interval at a weight oscillating object further again, impressing direct current voltage to an electrostatic-force impression electrode, and impressing electrostatic force to a weight oscillating object, the resonance frequency of the Z direction of a weight oscillating object can be adjusted, and angular velocity can be detected now with high density by tuning resonance frequency finely.

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[Translation done.]

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**CLAIMS**


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**[Claim(s)]**

[Claim 1] A weight oscillating object is connected through a connection beam inside a frame, and a flat-surface oscillating object is formed with the joint object of a frame and a weight oscillating object. As for this flat-surface oscillating object, vibration of the direction of X of X and 2 Y-dimensional flat surface is supported by the fixed substrate possible through the supporting beam. A mobile electrode is prepared in the heel of the aforementioned frame, and a fixed electrode is prepared in a fixed substrate side through this mobile electrode and an interval. Moreover, a fixed counterelectrode is prepared in the opposite side which minded this perpendicular slip lateral electrode and the interval while the perpendicular slip lateral electrode was prepared in the aforementioned weight oscillating object. The group of the aforementioned mobile electrode and a fixed electrode is constituted as an excitation electrode which vibrates a flat-surface oscillating object in the direction of X by electrostatic force. The group of the aforementioned perpendicular slip lateral electrode and a fixed counterelectrode is constituted as a circumference angular-velocity detection electrode of the Y-axis which detects the above X of the weight oscillating object corresponding to angular-velocity change of rotation of the circumference of the Y-axis, and the vibration amplitude of Z shaft orientations perpendicular to Y flat surface. The aforementioned connection beam is formed smaller than the rigidity of the direction of X whose rigidity of Z shaft orientations used as the detection oscillating direction of the aforementioned weight oscillating object is the oscillating direction of a flat-surface oscillating object. The aforementioned supporting beam is an angular-velocity sensor characterized by being formed smaller than the rigidity of Z shaft orientations from which the rigidity of the direction of X which is the oscillating direction of the aforementioned flat-surface oscillating object serves as the detection oscillating direction of the aforementioned weight oscillating object.

[Claim 2] The weight oscillating object is presenting the square configuration and the connection beam is presenting the L character configuration. The nose-of-cam side of the shorter side of the L character configuration of a connection beam is connected to the four-corners section of a weight oscillating object, respectively. The long side of the L character configuration of each connection beam is an angular-velocity sensor according to claim 1 characterized by \*\*\*\*(ing) towards the corner of the opposite side of the corner where the side of a weight oscillating object is made to meet through an interval in, and the nose-of-cam side of the shorter side of the aforementioned L character configuration is connected, and connecting the \*\*\*\* nose-of-cam side to a frame side.

[Claim 3] A connection beam is an angular-velocity sensor according to claim 1 characterized by being prepared in the direction of Y which intersects perpendicularly with the direction of X used as the oscillating direction of a flat-surface oscillating object.

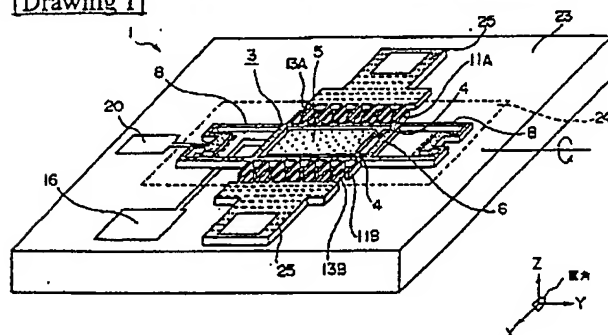
[Claim 4] The angular-velocity sensor of any one publication of the claim 1 characterized by preparing the electrostatic-force impression electrode for impressing electrostatic force to a fixed substrate side through a weight oscillating object and an interval at a weight oscillating object, or the claim 3.

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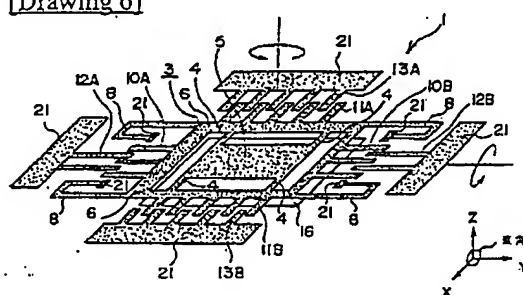
[Translation done.]

# DRAWINGS

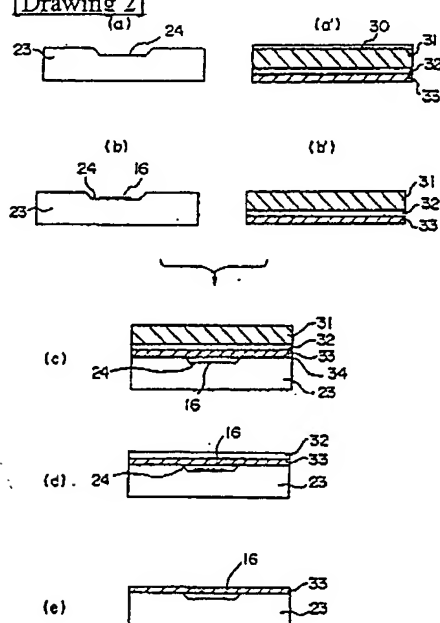
[Drawing 1]



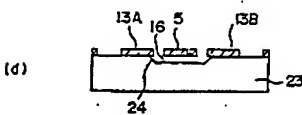
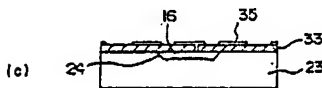
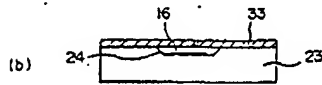
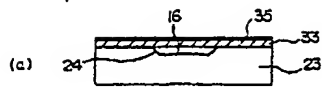
[Drawing 6]



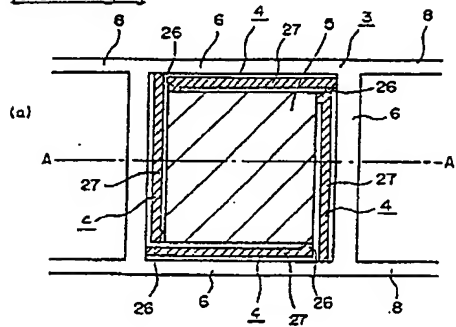
[Drawing 2]



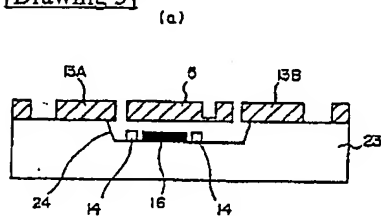
[Drawing 3]



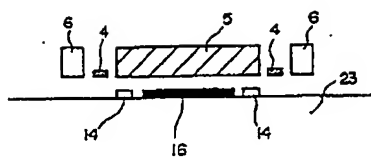
[Drawing 4]



[Drawing 5]



(b)



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[Translation done.]